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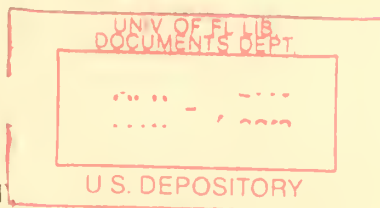
B. T. GALLOWAY, Chief of Bureau.

## SELF-BOILED LIME-SULPHUR MIXTURE AS A PROMISING FUNGICIDE.

BY

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# SELF-BOILED LIME-SULPHUR MIXTURE AS A PROMISING FUNGICIDE."

## INTRODUCTION.

The well-known toxic action of Bordeaux mixture on peach foliage, which renders it practically useless for the control of peach diseases in the growing season, led the writer to investigate other possible fungicides that might prove less caustic. Moreover, Bordeaux mixture, although remarkably beneficial in the control of fungous diseases, even stimulating the growth of plants in addition to its fungicidal effect, is unfortunately often injurious to the fruit and foliage of the apple and some other plants. The fruit russetting and foliage injury caused by Bordeaux mixture in the case of the apple has been the subject of much complaint in recent years, thus increasing the demand for a fungicide that can be used on growing plants without danger of injury.

The investigations of fungicides in which various sulphur compounds, as well as other substances, were tested, have extended over several years, but no satisfactory results were obtained until last season, when the self-boiled lime-sulphur wash was tried and proved to be sufficiently active to prevent fungous diseases without injuring the plants treated. Although the results reported in the following pages are exceedingly encouraging, it should be distinctly understood that this fungicide in the self-boiled form is in its experimental stage and

Owing to the remarkable progress that has been made in the treatment of plant diseases by fungicides anything new in this field is of the utmost importance and deserves the most careful attention on the part of investigators and fruit growers. This paper records a new step in the use of sulphur as a fungicide. Here we have for the first time a fungicide which apparently can be safely used on growing peach foliage. The susceptibility of peach foliage to injury by Bordeaux mixture and other copper sprays is so great as almost entirely to prevent their use in the treatment of peach diseases. On the apple the injurious effect in russetting the fruit and burning the foliage has to a much less extent but still seriously interfered with the otherwise successful use of copper. This situation makes the development of a fungicide which will obviate these difficulties of great importance. The results recorded are indeed remarkable and definite, but inasmuch as they depend on a single season's experiments, Mr. Scott has very properly cautioned fruit growers against their general application until they are corroborated by further experiments.—B. T. GALLOWAY, *Pathologist and Physiologist and Chief of Bureau.*

has not been sufficiently tested to justify its general recommendation. For the present, its use is advised for trial only, and the object of this preliminary paper is to show the rather striking results so far obtained and make them available to investigators and fruit growers as a basis for further experiments, in order that the value of the mixture may be more speedily determined. The Bureau of Plant Industry will continue the investigations, and it is hoped that at the end of another season definite recommendations can be made for the use of this wash or some modification of it in the treatment of orchard diseases.

A similar self-boiled wash has some slight reputation as a dormant treatment for the San Jose scale, and a few fruit growers have used it rather extensively for this purpose, but it seems to have had very little consideration as a fungicide and has apparently never been recommended for use on plants in foliage. Curiously enough, however, as early as 1833, before the general use of fungicides, Dr. William Kenrick<sup>a</sup> recommended for mildew on grapes a mixture of sulphur ( $1\frac{1}{2}$  pints), quicklime (a piece the size of the fist), and boiling water (2 gallons). This mixture, after cooling, was diluted with cold water and allowed to settle. The clear liquid was then drawn off and diluted to make a barrel full before using. In 1885 William Saunders<sup>b</sup> also recommended for pear-blight a self-boiled lime and sulphur wash consisting of 8 pounds of sulphur and one-half bushel of lime with boiling water, the mixture to be applied as a whitewash with brushes; and for mildews he advised applications of the clear sulphur liquid drawn off from this wash and greatly diluted.<sup>c</sup>

### SULPHUR AS A FUNGICIDE.

Sulphur has long been known to have fungicidal properties and has played an important part in the treatment of several plant diseases, notably the grape powdery mildew, rose mildew, and asparagus rust. Previous to 1880 it was almost the only fungicide in use, and it is to-day one of the best remedies for various mildews. In the form of potassium sulphid it has for years been the chief remedy recommended for gooseberry mildew and to a less extent for a few other diseases. The boiled lime-sulphur wash used as a dormant

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<sup>a</sup> The New American Orchardist, 1833, p. 328.

<sup>b</sup> Report, U. S. Commissioner of Agriculture, 1885, pp. 43 and 44.

<sup>c</sup> Since this article was prepared Prof. A. B. Cordley, of Oregon, has presented in the Rural New Yorker of March 7, 1908, p. 202, a summary account of his experiments in the use of dilute lime-sulphur sprays for apple scab, which sprays, made from the well boiled wash or from similar proprietary preparations, have also been tested on other fruit trees in foliage, such as the pear, peach, plum, prune, quince, and cherry, and on grapevines. The results obtained were thought to point strongly to the conclusion that lime-sulphur solutions may become a satisfactory substitute for Bordeaux mixture for summer spraying.

spray ranks close to Bordeaux mixture in the treatment of the peach leaf-curl and the California peach blight (*Coryneum bayerinckii* Oud.), a serious disease of the peach on the Pacific coast. On account of its caustic effect on the foliage of plants this boiled wash can not be used during the growing season and its usefulness as a fungicide is therefore restricted to diseases that can be reached in the dormant period; but the self-boiled mixture used in the experiments reported in this paper was entirely uninjurious to the foliage and fruit of both the peach and the apple.

#### THE SELF-BOILED LIME-SULPHUR MIXTURE.

At intervals during the past several years the writer has made experiments with sulphur and various sulphur compounds with the object of finding a fungicide that could be used during the growing period on fruit trees, especially the peach, without injury to the foliage or fruit. The first work was done in 1901, at the suggestion of Mr. M. B. Waite, and consisted of experiments with various sulphids, all of which proved injurious to peach foliage. During the season of 1907 self-boiled lime-sulphur mixtures in various proportions and strengths were tested on both the apple and the peach.

#### PREPARATION OF THE MIXTURE.

The mixture that gave the most promising results was composed of 10 pounds of sulphur (flowers or flour) and 15 pounds of fresh stone lime to 50 gallons of water,<sup>a</sup> and may be prepared as follows:

Place the lime in a 50-gallon barrel and pour a 2 or 3 gallon bucket of boiling water over it. Immediately add the sulphur and another bucket of hot water. The heat from the slaking lime will boil the mixture violently for several minutes. Some stirring is necessary to prevent burning, and more water should be added if the mass gets too thick to stir, but the cooking is more effectual when the minimum quantity of water is used, usually from 6 to 8 gallons being required. A piece of old carpet or gunnysack thrown over the top of the barrel helps to keep in the heat. The boiling will continue from twenty to thirty minutes, depending upon the quality of the lime. When the boiling ceases, dilute with cold water to make 50 gallons, stir thoroughly and strain through a sieve of about 20 meshes to the inch in order to take out coarse particles of lime, but all the sulphur should be carefully worked through.

In a similar manner, enough for 150 gallons may be prepared in a barrel by using 30 pounds of sulphur and 45 pounds of quicklime, with about 20 gallons of boiling water. When the boiling ceases, the barrel should be filled with cold water and diluted with 100 gallons more when transferred to the spray tank.

<sup>a</sup>See note on page 18.



In some of the experiments a wash consisting of 5 pounds of sulphur and 10 pounds of lime to 50 gallons of water gave excellent results. This would indicate that a much more dilute mixture than the 10-15-50 formula may prove to be a satisfactory fungicide. The wash was also prepared with cold water instead of boiling water, and in some cases a portion of the lime was at first withheld and later added, a small lump at a time, in order to prolong the boiling; but the experiments have not yet been sufficient to determine definitely the correct formula and the best method of preparation.

Should the boiling be very prolonged the mixture might become caustic enough to burn foliage, although no such injury developed in the experiments. If it should be found in practice that the use of hot water dissolves too much sulphur, so that the foliage is injured, cold water may be substituted and a less intense heat thus developed, or the sulphur can be withheld until the lime has partly slaked, thus regulating the amount of sulphur dissolved.

By this boiling process the sulphur is put in good mechanical condition for spraying, and enough of it is dissolved to make the mixture adhesive. As a large percentage of the sulphur is simply held in mechanical mixture with the lime water, it is necessary that the spraying outfit be provided with a good agitator, so that the mixture may be kept constantly stirred, and settling be thus avoided. In the treatment of apple trees, Paris green may be added for the control of the codling moth in the same manner as when Bordeaux mixture is used.

#### APPLE BITTER-ROT EXPERIMENTS.

The work on apples was done at Bentonville, Ark., and the principal disease involved was bitter-rot (*Glomerella rufomaculans* (Berk.) S. and v. S.). This disease began to appear in the orchard of Capt. George T. Lincoln on July 8, 1907, and on July 12 the writer, assisted by Mr. James B. Rorer, sprayed a block of 24 trees with this lime-sulphur mixture, adding 6 ounces of Paris green to each 50 gallons; a second block of 24 trees with the same mixture, substituting 2 pounds of arsenate of lead for the Paris green, and a third block of about 100 trees with Bordeaux mixture (5 pounds of bluestone and 5 pounds of lime to 50 gallons of water) and arsenate of lead. A block of 24 trees was left untreated as a check. About half of the trees in each block were Ben Davis and the other half Givens.

These treatments were repeated on July 26 and again on August 27, 1907. When the first application was made (July 12) some bitter-rot was showing on both varieties, as many as fifteen or twenty affected fruits being found on a number of individual trees. Although the season was comparatively dry, the showers that came at rather long



intervals permitted of infections sufficient to destroy a large portion of the crop on the untreated trees.

The crop of Ben Davis apples was picked on September 17 and 18, and the Givens on October 10. The apples, including the windfalls, from several average trees of each plot were sorted with reference to bitter-rot into diseased and sound fruit. The results are shown in Tables I and II.

TABLE I.—*Apple bitter-rot on Ben Davis trees. Comparative results from treatment with lime-sulphur mixture and Bordeaux mixture, and from checks.*

Trees sprayed July 12 and 26 and August 27, 1907.		Number of sound apples.	Number of diseased apples.	Percentage of sound fruit.
Lime-sulphur mixture:				
Tree No. 3.....		1,651	164	90.96
Tree No. 4.....		510	40	92.72
Tree No. 5.....		1,256	98	92.02
Bordeaux mixture:				
Tree No. 7.....		791	29	96.46
Tree No. 8.....		572	52	91.65
Tree No. 13.....		1,582	118	93.05
Trees not sprayed:				
Check C.....		215	1,055	16.85
Check D.....		144	611	19.08
Check E.....		142	1,352	9.50

Although bitter-rot was severe enough on the Ben Davis trees to destroy from 80 to 90 per cent of the crop on the unsprayed trees, the lime-sulphur mixture held it down to less than 10 per cent of the crop, as shown in Table I. See also figures 1 and 2. In this experiment the sulphur wash compared favorably with Bordeaux mixture, the latter giving only slightly better results. The disease had a considerable start on the Ben Davis trees before the first application was made, and this accounts for at least a part of the diseased fruit on the sprayed trees. Slightly better results with both the sulphur and the copper treatments could probably have been secured had the first application been made a week earlier.

TABLE II.—*Apple bitter-rot on Givens trees. Comparative results from treatment with lime-sulphur mixture and Bordeaux mixture, and from checks.*

Trees sprayed July 12 and 26 and August 27, 1907.		Number of sound apples.	Number of diseased apples.	Percentage of sound fruit.
Lime-sulphur mixture:				
Tree No. 1.....		2,034	18	99.02
Tree No. 2.....		1,828	23	98.75
Tree No. 3.....		626	20	96.90
Bordeaux mixture:				
Tree No. 4.....		806	1	99.87
Tree No. 5.....		1,458	178	89.12
Tree No. 6.....		1,761	16	99.10
Trees not sprayed:				
Check A.....		721	844	46.07
Check C.....		1,257	815	60.66
Check D.....		257	423	37.79

Bitter-rot was not so bad on the Givens as on the Ben Davis trees, but somewhat more than half of the crop on the unsprayed trees was destroyed by it, while the fruit sprayed with the lime-sulphur mixture, as well as that sprayed with Bordeaux mixture, was only slightly affected.

It would appear from these tables that the two fungicides are equally effective against bitter-rot and that when desired the lime-sulphur mixture may be substituted for Bordeaux mixture in the treatment of this disease. These results show that the self-boiled lime-sulphur mixture is an excellent fungicide under the conditions attending this experiment. The only question that remains is



FIG. 1.—Crop of apples from a Ben Davis tree sprayed three times with self-boiled lime-sulphur mixture. The sound fruit (92 per cent) is in the pile on the ground and the fruit affected with bitter-rot is in the basket.

whether it will maintain this high standard under more unfavorable conditions, such as extremely wet weather.

So far as the writer could observe, absolutely no injury to the fruit or foliage developed from the use of this wash, and it adhered almost, if not quite, as well as Bordeaux mixture. At picking time the foliage was still white with the mixture and the fruit had a good coat of it. Again, however, it must be remembered that the season was comparatively dry, the rainfall for July being only 0.81 inch and for August 3.76 inches. Although the mixture seems to be quite adhesive, heavy beating rains might take it off the fruit and foliage, so that a large part of its fungicidal value would be lost.

## EXPERIMENTS IN THE TREATMENT OF OTHER APPLE DISEASES.

## APPLE BLOTCH.

Another experiment was conducted on Ben Davis trees in the orchard of Mr. Jefferson. The principal disease involved was apple blotch (*Phyllosticta solitaria* E. and E.). Both the lime-sulphur and Bordeaux mixtures were used here, as in the Lincoln orchard. Owing to unavoidable delays the first application was not made until June 11, 1907, when the disease had already gained a good foothold. A second application was made on July 8. The fruit on the trees sprayed with the lime-sulphur wash, as well as that sprayed with Bordeaux mixture,



FIG. 2.—Crop from an untreated Ben Davis tree in the same orchard as that shown in figure 1. The fruit affected with bitter-rot (90.5 per cent) is in the pile on the ground and the sound fruit is in the basket.

held up without further infection, while the checks continued to go down until practically the entire crop was destroyed by this disease. This is hardly sufficient evidence to justify the conclusion that the apple blotch disease will readily yield to the lime-sulphur treatment, but these results strongly indicate as much.

No apparent injury whatever resulted from the use of the self-boiled wash in this orchard. However, a wash consisting of 3 pounds of sulphur and 5 pounds of lime to 50 gallons of water, boiled 45 minutes, when applied to a few apple trees burned the leaves considerably and caused some defoliation, showing that the boiled mixture is unsafe for use on apple foliage.

## APPLE LEAF-SPOT.

In both the Lincoln and the Jefferson orchards the foliage on the trees sprayed with the lime-sulphur wash did not become affected with the leaf-spot disease (*Spilocapsis malorum* Pk.), except from some early infections that took place before the treatment was made. The leaves on these trees remained fresh and green until frost. On the other hand, the unsprayed trees left as checks were partly defoliated a month or more before the normal period of leaf fall. It appears, therefore, that the leaf-spot disease may be readily prevented by the use of this lime-sulphur wash.

## APPLE SCAB.

Very little scab (*Venturia inaequalis* (Cke.) Adh.) occurred in either orchard, and no definite data on the control of this disease were obtainable. The results with bitter-rot, however, were so excellent as to indicate that similar success with this wash might be expected in the treatment of apple scab, and perhaps pear scab as well. Bordeaux mixture has been so efficient in the control of scab that it would seem undesirable to replace it with another fungicide except to avoid the russetting of the fruit and the foliage injury often following its use.

EXPERIMENTS IN THE TREATMENT OF PEACH DISEASES.<sup>a</sup>

The work on the peach was done in the orchard of Hitt Brothers, at Koshkonong, Mo., in cooperation with the Missouri Fruit Experiment Station, Messrs. F. W. Faurot and T. W. Ayres assisting. A block of 6-year-old Elberta trees was divided into 30 plots of 5 trees each and several different mixtures in addition to the self-boiled lime-sulphur wash were tried. Bordeaux mixture used in several different strengths was so injurious to the foliage that it was mostly dropped from the experiment after the second treatment; sulphuric acid, 1 part to 1,000 parts of water, not only defoliated the trees but caused the entire crop of fruit to drop; and a lime-sulphur wash consisting of 1½ pounds of sulphur and 3 pounds of lime to 50 gallons of water, boiled forty-five minutes, burned the leaves and partly defoliated the trees.

## PEACH BROWN-ROT AND SCAB.

The self-boiled lime-sulphur mixture heretofore described did not injure the peach foliage or fruit and proved to be a strong fungicide in its effect on both brown-rot and peach scab, as well as on some

<sup>a</sup> In a paper before the American Pomological Society, read on September 25, 1907, the writer gave a summary of these experiments and outlined the principal results obtained.

leaf diseases. Unboiled sulphur with milk of lime and pure sulphur suspended in water were also used with promising results.

The treatments of the several plots of most interest and the results on brown-rot (*Sclerotinia fructigena* (P.) Sehrt.) and scab, or black-spot (*Cladosporium carpophilum* Thüm.), are condensed in the following table:

TABLE III. *Treatments and results of experiments obtained with fungicides on brown-rot and scab of peach.*

Plot	Mixtures used.	Dates of spraying, 1907.					Total fruits	Peaches affected with brown-rot.		Peaches affected with scab.	
		May	June	June	July	July		No.	P. ct.	No.	P. ct.
1	Lime-sulphur (10-15-50) <i>a</i> , self-boiled	22	6	20	5	13	1,329	138	10.4	56	4.3
2	Lime-sulphur (5-10-50) self-boiled	22	6	20	5	13	2,426	250	10.3	227	9.3
3	Sulphur and lime milk (10-10-50)	22	6	20	5	13	1,574	220	14	109	6.9
4	Sulphur water (10-50)	22	6	20	5	13	1,055	301	30	44	3.4
20	Lime-sulphur (10-15-50) self-boiled		6	20	5	13	1,132	212	18.7	90	7.8
23	Lime-sulphur (10-15-50) self-boiled				2		1,269	252	19.8	373	29.4
24	Lime-sulphur (10-15-50) self-boiled				2		1,356	507	37.4	523	38.6
27	Bordeaux mixture (1-5-50)				2	13	1,796	381	21.2	728	40.5
Check	10 untreated trees						1,970	1,444	73.3	555	28.1

*a* 10 pounds of sulphur and 15 pounds of quicklime to 50 gallons of water.

Plot 1, as shown in the foregoing table, was sprayed five times with a self-boiled lime-sulphur mixture composed of 10 pounds of sulphur and 15 pounds of quicklime to 50 gallons of water, prepared in the same manner as described on page 7. The trees were sprayed on May 22, June 6, June 20, July 5, and July 13, 1907, the last date being about two weeks before the fruit matured. The crop was picked from July 30 to August 7, and the five trees yielded 1,329 fruits, 10.4 per cent of which were affected with brown-rot. This seems rather encouraging when 73.3 per cent of the crop on the check trees in adjacent rows rotted. Moreover, only 4.3 per cent of the crop showed any marks of scab, and most of these were very small, almost unnoticeable specks. Mr. Ayres, who was on the ground constantly, reports that the leaves showed no injury at any time during the season, and when the writer made a final examination on August 27 the foliage was still green and apparently uninjured. The mixture had adhered so well that the leaves and branches were whitish on that date.

Plot 2 had the same treatment as plot 1, except that the formula in this case was reduced to 5 pounds of sulphur and 10 pounds of lime to 50 gallons of water. The results were about the same as in the first plot, 10.3 per cent of the crop being affected with brown-rot and 9.3 per cent with scab. The foliage was uninjured and the



mixture adhered well throughout the summer. This would indicate that a weaker mixture than that used in plot 1 may prove to be satisfactory, thus cheapening the treatment.

Plot 3 was sprayed on the same dates as plots 1 and 2 with an unboiled sulphur and lime-milk mixture composed of 10 pounds of sulphur and 10 pounds of lime to 50 gallons of water. The lime was slaked in the ordinary way and the sulphur worked into it, forming a paste. Then the mixture was diluted to make 50 gallons. This mixture was more difficult to apply, required more agitation, and did not adhere so well. However, it held the rot down to 14 per cent of the crop and the scab to 6.9 per cent, indicating that it has considerable fungicidal value.

Plot 4 was sprayed on the same dates as the three plots previously mentioned with 10 pounds of sulphur suspended in 50 gallons of water. The sulphur was worked into a paste and then diluted. The rot on this plot was 30 per cent of the crop, and the treatment for this disease was therefore practically a failure. However, only 3.4 per cent of the fruit was affected with scab. The sulphur without the lime seems to have been entirely sufficient to control this disease. Sulphur settles readily in water and is rather difficult to keep in suspension.

Plot 20 was sprayed with the same self-boiled mixture as plot 1, and the applications were made on the same dates, except that in this case the first application (May 22) was omitted. The percentage of rot, 18.7 per cent, was rather high, owing apparently to the omission of the May treatment. However, only 8.8 per cent of the crop was affected with scab. A few scab infections had taken place before the treatment was begun, and on unsprayed trees this disease developed quite rapidly after the middle of June.

Plot 23 was sprayed on July 2 and 13 with the same self-boiled mixture used on plots 1 and 20, only two applications being made. Of the crop, 19.8 per cent rotted and 29.4 per cent was affected with scab. The fruit was already badly "scabbed" before the treatment was begun, and the cracking due to this disease opened the way for brown-rot.

Plot 24 was sprayed on July 2 with the same mixture as plots 1, 20, and 23. Only one application was made, and it was quite insufficient for both brown-rot and scab, 37.4 per cent of the crop being affected with the former disease and 38.6 per cent with the latter.

Plot 27 was sprayed with Bordeaux mixture consisting of 1 pound of copper sulphate, 5 pounds of lime, and 50 gallons of water. The applications were made on July 2 and 13, with the result that 21.2 per cent of the crop was affected with brown-rot and 40.5 per cent with scab. The treatment was entirely too late for scab, but had some

effect on brown-rot. These results were about the same as those secured on plot 23, which was sprayed on the same dates with the self-boiled lime-sulphur mixture. The plots on which spraying with Bordeaux mixture was commenced on May 22, when the sulphur treatment was begun, were abandoned on account of severe foliage injury. These plots, not having been carried through the season, are omitted from the table.

On the check plot, consisting of 10 untreated trees located in rows adjacent to the sprayed rows, 73.3 per cent of the crop was affected with brown-rot and 28.1 per cent with scab.

A glance at Table III shows that sulphur, wherever used in this experiment, whether self-boiled or unboiled, applied once or oftener, had more or less effect on the brown-rot disease. Where the self-boiled wash of both full strength and half strength was used, nearly 90 per cent of the crop came through free from the disease. Owing, perhaps, to the late spring frosts, some of the peach pits cracked and there was considerable proliferation around them, which resulted in a cracking of the skin, thus exposing the fruit even on sprayed trees to brown-rot infection. This, together with insect punctures, partly accounts for the 10 per cent of loss on plots 1 and 2. A comparison of these two plots indicates that 5 pounds of sulphur in the mixture is just as good as 10 pounds, the larger quantity apparently being unnecessary.

It must be understood that the writer does not consider this single series of experiments sufficient to justify final conclusions upon which to base orchard practice. Not until these results have been verified under different conditions can the treatment be recommended with full confidence.

It is not at all surprising that this sulphur mixture should be a good fungicide; the gratifying surprise is that it does not injure peach foliage. Under different weather conditions or when boiled with a more active grade of lime it might prove injurious, and for this reason caution should be exercised until further knowledge of its action is obtained.

Although occasional rains occurred at Koshkonong, Mo., while the experiment was in progress, the season would be considered rather dry. The rainfall there as recorded by the voluntary observer, Mr. John W. Hitt, was as follows: For the month of May, 10.89 inches; June, 4.9 inches; and July, 1.67 inches. Enough rain fell to produce considerable injury to peach foliage following applications of Bordeaux mixture and to cause a severe outbreak of brown-rot. During a very wet season, however, the treatment might not be so successful; in fact, this disease is influenced by so many factors that it seems doubtful whether an entirely satisfactory treatment for it will ever be



found. The plum curculio punctures the skin of a certain percentage of the fruit and thus admits the fungus in spite of all spraying that can be done; also, some of the leaf-footed plant bugs feed on the rotting and the sound fruit indiscriminately, thus undoubtedly distributing the fungus and perhaps even with their beaks inserting the spores beneath the skin of the fruit. It seems quite impossible to protect against such infections.

In the case of peach scab the results were very decided. In every plot where sulphur was used before infection took place, this disease was almost completely controlled. Even sulphur suspended in water without the addition of lime seems to be sufficient to control this disease. As a rule, the scab infections on the sprayed fruit were manifested in small specks instead of the large spots and cracks that were so common on the unsprayed fruit.

#### PEACH-LEAF DISEASES.

The frosty mildew (*Cercospora persicae* Sacc.) was also controlled by the self-boiled lime-sulphur mixture (10-15-50). This was demonstrated especially on Picquet's Late, which variety was sprayed on July 26 and again on August 8. The writer examined the trees on August 27 and found the foliage in a vigorous, healthy condition, practically free from leaf diseases, while the leaves of the unsprayed trees were badly affected with the frosty mildew, had turned yellow, and were falling considerably. Some of these leaves were also affected with a shot-hole disease due apparently to *Bacterium pruni* Smith, but none of this could be found on the sprayed trees.

#### A COMBINED FUNGICIDE AND INSECTICIDE.

Self-boiled lime-sulphur washes used in the dormant spraying of fruit trees are known to have some effect against the San Jose scale, and in order to avoid the expense of a cooking plant a few growers have employed this method of preparing the wash. Entomologists have wisely discouraged the use of self-boiled washes because of their inferiority to the boiled preparations, but when used as a fungicide in the growing season a self-boiled lime-sulphur wash might be expected to aid considerably in the control of the San Jose scale and other scale insects by the destruction of the crawling lice, and would thus perhaps prevent the infestation of the fruit, a condition especially likely to occur with apples and pears. This would give it a decided advantage over Bordeaux mixture and make it especially useful as a combined fungicide and insecticide in the treatment of large apple trees on which the scale is so difficult to control. Summer applications for the prevention of fungus diseases would thus sup-

plement the dormant treatment of the San Jose scale without extra cost.

Sulphur is also a well-known remedy for various mites, and the self-boiled wash would probably be of considerable value in the control of the red spider.

#### RANGE OF POSSIBLE USEFULNESS.

The fungicide described in these pages is only in the experimental stage, and it is impossible to predict the extent of its usefulness; but if it will control apple bitter-rot, as the results so far obtained indicate, it would naturally be expected to prevent apple scab. Although no positive results were obtained with this disease, the indications were that it might easily be controlled with the lime-sulphur wash and the fruit russetting and foliage injury due to the use of Bordeaux mixture thus avoided. Except the injury following its use in a wet season, Bordeaux mixture furnishes an entirely satisfactory fungicide for both apple scab and bitter-rot, perhaps better than can be expected of the lime-sulphur wash; but the latter has the advantage of being a combined insecticide and fungicide and does not injure the fruit or foliage, or at least it would so appear from these preliminary experiments.

This self-boiled mixture could reasonably be expected to readily control the powdery mildews of fruit, some of which have long been known to be preventable by the application of sulphur in some form. Owing to its greater adhesiveness, it should perhaps largely supplant dry sulphur and liver of sulphur in the treatment of various mildews.

If the results of last year's experiments are borne out by further tests, the most important function of this fungicide will doubtless be the control of peach diseases. Heretofore, practically no known fungicide could be used on peach foliage without injurious results, and for this reason orchardists have been unable to combat some of the more important peach diseases and to prevent the annual loss of several millions of dollars' worth of fruit caused by them. Bordeaux mixture, the standard fungicide, can not be used on peach trees during the growing season without danger of serious injury to the foliage. While a weak Bordeaux mixture may be used in a dry season without injurious results, the same mixture applied in a wet season, when most needed, will usually defoliate the trees. The other forms of copper, such as ammoniacal copper carbonate and acetate of copper, are even more toxic than Bordeaux mixture.

It is apparent, then, that an efficient cheap fungicide that can be used on the fruit and foliage of the peach without injurious results will be of inestimable value. The self-boiled lime-sulphur mixture gives promise of meeting these requirements, and it is hoped that

the results already secured will be substantiated by further investigations. Under some unfavorable weather conditions injury to the foliage or fruit might possibly develop, and heavy beating rains might wash the sulphur away, so that its fungicidal effect would be partly lost. It seems likely, however, that a lime-sulphur mixture, either self-boiled or unboiled, will prove to be a safe and valuable fungicide for use on fruit trees and other plants during the growing season.

Approved:

JAMES WILSON,

*Secretary of Agriculture.*

WASHINGTON, D. C., *March 14, 1908.*

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NOTE TO THE SECOND EDITION.—Since the first edition of this circular was issued, additional results of the season's work of 1908 have become available, particularly the results of experiments in spraying the peach at Marshallville, Ga. It has been found that too much sulphur was brought into solution when hot water was used in slaking the lime, especially when material sufficient for 200 or 300 gallons was made up at one time. Under the warm, rainy, humid conditions that occurred at one period in Georgia some injury resulted to the peach foliage, there being enough soluble sulphids in the solution to burn the leaves. When cold water was used in slaking the lime, only a small quantity of sulphur is actually brought into solution and no harm, or a very insignificant amount, occurred. For use on the peach and Japanese plum, therefore, cold water instead of hot water is advisable for slaking the lime.

Furthermore, it was found that 5 pounds of sulphur to 5 pounds of lime is entirely sufficient for spraying peach trees, so that this formula is now recommended. Where the precaution of mixing with cold water was taken no injury to peach foliage resulted. On the apple the stronger mixture made with hot water can be used. It is doubtful, however, whether more than 8 or 10 pounds of sulphur and the same quantity of lime need be applied on the apple for the best results.

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